3.3.5. Dynamic Update Performance

3.3.5.1. Purpose

The purpose of this test is to evaluate the functionality and accuracy of the INS position update modes and to assess their utility in a tactical environment.

3.3.5.2. General

As explained in the navigation theory section, the long term accuracy of the INS is usually enhanced through periodic manual updates. The update modes allow resetting the displayed position to a given reference point or to a known bearing and range from a given reference point. The sample INS used in this book can be updated using a visual flyover (or waypoint) mode, radar, TACAN and OMEGA modes. The waypoint update is performed similar to the flyover point method. The latitude and longitude of the flyover point are loaded into the INS computer as a waypoint. At the instant the point is visually overflown an update is made and the INS latitude and longitude are changed to the waypoint latitude and longitude. During a radar update, the position of the radar target is loaded as a waypoint. The radar target is designated on the radar display and the bearing and range to the target are automatically converted to an offset of latitude and longitude from the known radar target position. This radar offset latitude and longitude becomes the current position at the time the update is performed. In a TACAN update, the TACAN ground station position is loaded as a waypoint and the TACAN radial and DME are used in a fashion similar to the radar bearing and range to provide a latitude and longitude offset at the time the update is performed. In the OMEGA update, the OMEGA calculated latitude and longitude are used directly to update the INS current position.

As with the flyover method, the waypoint update accuracy is approximately equal to 1/2 of the height above the update point, assuming an accurately surveyed update point position is known. The radar and TACAN update accuracies depend upon the surveyed position accuracy of the radar target and TACAN ground station, the bearing and range accuracy of the radar and accuracy of the TACAN. A method for determining the bearing and range accuracy of an air-to-ground radar was described in the radar theory section and as described in the navigation theory section, the expected TACAN accuracy is approximately 3.5° and 0.1 to 3 nm. The OMEGA update accuracy depends upon the position fixing accuracy of the OMEGA itself. As was explained earlier, the only parameter updated is the position, the rate of the drift will not be affected significantly by the update.

3.3.5.3. Instrumentation

Data cards and an optional voice recorder are required for this test.

3.3.5.4. Data Required

Prior to the first update, record the initial flyover data point elapsed time, displayed latitude and longitude and the flyover altitude. After performing each update, record the flyover elapsed time, displayed latitude and longitude and altitude. For each flyover data point and for the waypoint update, record the offset bearing and range, if applicable, as notes. During the entire flight, record qualitative comments concerning the utility of the INS update modes including the ease of the updates, utility of the controls used for each update, the integration of the INS with the TACAN, radar and OMEGA used in the updates as well as the update accuracy.

3.3.5.5. Procedure

Prior to the test flight, select a flyover point in a working area (preferably a Restricted Area) that allows maneuvering for repeated flyover passes. Select a surveyed radar target close enough to the flyover point to be within the detection volume of the radar while overhead the flyover point. Finally, find the latitude, longitude, channel and identifier code for the TACAN station closest to the flyover point. Choose an airspeed that conserves fuel. Since a number of flyover points will be performed in rapid succession, the entire test should be flown from approximately 200 to 2,000 feet AGL. The lowest altitude that can be flown considering the maneuvering characteristics of the aircraft, the qualifications of the pilot and the local terrain should be chosen. The TACAN may be switched through channels as required to navigate to the flyover point. After the initial flyover point is performed, limit all maneuvers to 1.5g or less, 30° angle of bank, 20° of pitch and less than 50 KIAS of airspeed change to isolate the effects of aircraft maneuvers from the effects of the update accuracy. In addition, perform the flyover data points as quickly after the updates as possible to reduce the amount of drift in the INS between the update and the flyover point.

Perform a waypoint update using the published procedures for the INS and the same flyover point used for the flyover data. Record the altitude above the update point. If necessary, repeat the waypoint update until little or no offset is noted at the update point. Following the final waypoint update, perform a flyover data point, recording the displayed latitude and longitude and the flyover altitude and then turn outbound towards the chosen radar target. Using the published aircraft procedure, perform a radar update of the INS and then repeat the flyover data point. Next, dial in the TACAN station chosen during preflight (if it is not already being used) and after the TACAN is properly tracking the ground station, perform a TACAN update of the INS in accordance with the published procedure. Perform a third flyover data point. Finally, perform an OMEGA update in accordance with the published procedures and then perform the last flyover data point. Throughout the flight, record INS alerts along with the time of occurrence, as notes. Thoroughly investigate all failure indications after the flight. In addition, qualitatively assess the utility of the INS update modes including the ease of the updates, the utility of the controls used for each update, the integration of the INS with the TACAN, radar and OMEGA used in the updates, as well as the update accuracy.

3.3.5.6. Data Analysis and Presentation

For flyover point data where the aircraft did not fly directly over the flyover point, use the recorded bearing and range at CPA to find the actual latitude and longitude. Convert the bearing to the point to true bearing and then resolve the vector into north-south and east-west components. Next, convert the components into differences in latitude and longitude. In the north-west hemisphere, add the difference in latitude when the point is to the south of the aircraft. Add the difference in longitude when the point is to the west of the aircraft. Use the equations below:

$$T_{bearing} = M_{bearing} - V$$
$$\Delta_{Lat} = \frac{(\Delta nm)}{\left(1\ \frac{nm}{min}\right)} \qquad (26)$$
$$\Delta_{Long} = \frac{(\Delta nm)}{\left[\left(1\ \frac{nm}{min}\right)(\cos(LAT))\right]}$$

Subtract the displayed latitude and longitude from the surveyed latitude and longitude or the offset corrected latitude and longitude as appropriate. Convert the latitude and longitude difference to nm using equation (21). Since the flyover points are taken immediately after the updates, the errors can be used to closely represent errors in the updates. Compare the noted errors to the expected accuracies of the update sources. The expected accuracy of the waypoint update is 1/2 of the height above the update point. The radar accuracy is as measured during the bearing and range accuracy test. The TACAN accuracy is around 3.5° and 0.1 to 3 nm as described in the navigation theory section. The OMEGA accuracy is approximately 1 nm in the daytime and 2 nm at night. Relate the accuracy of the update (both expected and unexpected) to the navigational accuracy required to safely ingress to the target area for an attack aircraft and for the necessity to find the home field in IMC conditions after a mission for the fighter aircraft.

Thoroughly investigate any INS alerts that imply degraded accuracy. Alerts that do not result in malfunctions being found during the ground check should be related to the possibility of unnecessarily aborted sorties (false alarms). Relate the ease with which each update is performed to the requirement to perform the updates in a highly stressful combat environment and while simultaneously performing other functions such as avoiding enemy defenses. Relate the integration of the INS, radar, TACAN and OMEGA controls within the same context. Relate the utility of the displays used during the INS update to the effect that performing the update has upon the scan of other vital tactical information such as visually scanning for surface to air missiles.

3.3.5.7. Data Cards

Sample data cards are provided as card 42.

CARD NUMBER ___ TIME _____ PRIORITY L/M/H

DYNAMIC UPDATE PERFORMANCE

[INSURE TACAN AND OMEGA ARE TURNED ON AND INITIALIZING. SET ___KIAS, CLIMB TO ___MSL AND ASSUME NAVIGATION TO FLYOVER. RESTRICT MANEUVERING TO 1.5 G, 30° ANGLE OF BANK, 20° OF PITCH AND 50 KIAS OF AIRSPEED CHANGE. PERFORM EACH UPDATE AND BETWEEN EACH TAKE A FLYOVER DATA POINT. REPEAT THE WAYPOINT UPDATE UNTIL OPTIMIZED. RECORD AS NOTES, OFFSET FROM THE POINT, AS WELL AS SYSTEM ALERTS. RECORD QUALITATIVE COMMENTS CONCERNING THE UTILITY OF THE UPDATE MODES INCLUDING THE EASE OF UPDATE, UTILITY OF THE CONTROLS USED FOR EACH UPDATE, INTEGRATION OF THE INS WITH THE TACAN, OMEGA AND RADAR SYSTEMS USED IN THE UPDATES, AS WELL AS THE UPDATE ACCURACY.]

FLYOVER POINT __________ __________

DESCRIBE POINT:

RADAR TARGET __________ __________

DESCRIBE TARGET:

UPDATE TACAN POSITION __________ __________

TACAN CHANNEL/IDENTIFIER ___/____

Card 42: Dynamic Update Performance Data Cards

DYNAMIC UPDATE PERFORMANCE

WAYPOINT UPDATE ALTITUDE (FT MSL)/OFFSET _____/_____

UPDATE	DISPLAYED	FLYOVER ALT (FT MSL)	NOTES:
WAYPOINT			
RADAR			
TACAN			
OMEGA			

NOTES:

Card 42: Dynamic Update Performance Data Cards (Continued)

DYNAMIC UPDATE PERFORMANCE

QUALITATIVE COMMENTS CONCERNING THE UTILITY OF THE INS UPDATE MODES INCLUDING THE EASE OF THE UPDATES:

UTILITY OF THE UPDATE CONTROLS/DISPLAYS:

INTEGRATION OF THE INS WITH THE RADAR/TACAN/OMEGA SYSTEMS:

NOTES:

Card 42: Dynamic Update Performance Data Cards (Continued)